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5001

UNIVERSAL COUNTER - TIMER

GLOBAL SPECIALTIES

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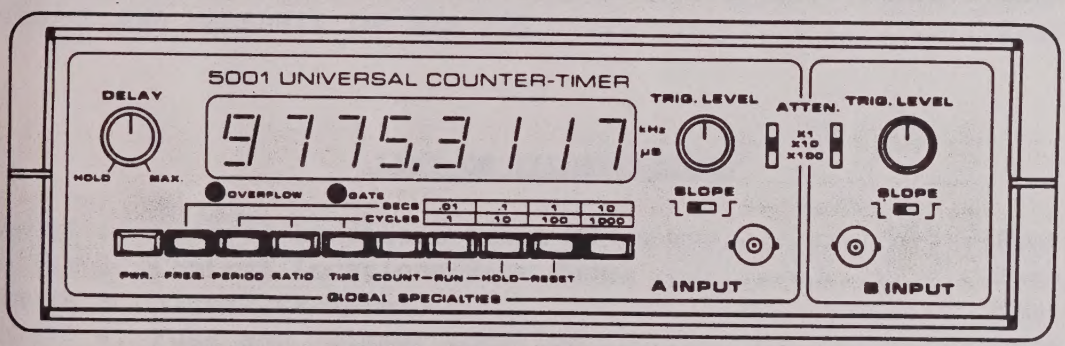
# 5001 UNIVERSAL COUNTER-TIMER




# INSTRUCTION, OPERATION AND APPLICATION MANUAL

-01-0037
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# 5001 SPECIFICATIONS

## INPUTS:

**FRONT PANEL** — 2 inputs, A and B. DC coupled, BNC connectors

**A INPUT:**

| | |
|---|---|
| Impedance | 1 Megohm // 25 pF |
| Response | DC to 10 MHz |
| Sensitivity | 20 mV RMS |
| Attenuator | X1, X10, X100 switch selectable |
| Trigger Level Range | -0.5v to +0.5v times attenuator setting |
| Slope Select | rising edge, falling edge switch selectable |
| Max. Input Voltage | X1 Atten:<br>+/-400v peak, DC to 30 kHz<br>+/-100v peak, 30 kHz to 100 kHz<br>+/-20v peak, 100 kHz to 1 MHz<br>+/-5v peak, 1 MHz to 10 MHz<br>X10 Atten:<br>+/-400v peak, DC to 1 MHz<br>+/-50v peak, 1 MHz to 10 MHz<br>X100 Atten:<br>+/-400v peak, DC to 10 MHz |

**B INPUT:**

| | |
|---|---|
| Impedance | 1 Megohm // 25 pF |
| Response | DC to 2 MHz |
| Sensitivity | 20 mV RMS |
| Attenuator | X1, X10, X100 switch selectable |
| Trigger Level Range | -0.5v to +0.5v times attenuator setting |
| Slope Select | rising edge, falling edge switch selectable |
| Max. Input Voltage | X1 Atten:<br>+/-400v peak, DC to 30 kHz<br>+/-100v peak, 30 kHz to 100 kHz<br>+/-20v peak, 100 kHz to 1 MHz<br>+/-10v peak, 1 MHz to 2 MHz<br>X10 Atten:<br>+/-400v peak, DC to 1 MHz<br>+/-100v peak, 1 MHz to 2 MHz<br>X100 Atten:<br>+/-400v peak, DC to 2 MHz |

**REAR PANEL** — 1 input, external timebase. DC coupled, BNC connector

| | |
|---|---|
| Impedance | 1 Megohm // 25 pF (1k above +5v or below 0v input) |
| Response | 100 kHz to 10 MHz, 50 ns pulse width minimum |

| | | |
|---|---|---|
| | Input Requirement | TTL levels |
| | Max. Input Voltage | +20v, -15v |
| **REFERENCE:** | Crystal Oscillator | |
| | Frequency | 10 MHz |
| | Aging Rate | <4 ppm/year |
| | Temperature Stability | +/-4 ppm, 5C to 35C |
| **MODES:** | Frequency | 10 MHz max; 4 ranges with gate times of 0.01/0.1/1.0 /10 seconds; display in kHz; A input only |
| | Period | 400 ns to 10 sec; 4 ranges with 1/10/100/1000 cycle average; display in microseconds; A input only |
| | Frequency Ratio | 10 MHz max into A input, 2 MHz into B input; 4 ranges, counts cycles at A input over 1/10/100/1000 cycles at B input. |
| | Time Interval | 200 ns to 10 sec; 4 ranges with 1/10/100/1000 measurement cycle average (one measurement cycle being the time interval from the selected edge at the A input to the selected edge at the B input). |
| | Event Count | 10 MHz max;counts to 99,999,999; one range; A input only. |
| **ACCURACY:** | Frequency | +/- (time base error X frequency) +/- 1 LSD. LSD displayed - 100/10/1/0.1 Hz for 0.01/0.1/1.0/10 second gate times |
| | Period | +/- (timebase error X period) +/- ((trigger error*/cycles averaged) X period) +/- 1 LSD; LSD displayed - 100/10/1/0.1 ns for 1/10/100/1000 cycles averaged |
| | Frequency Ratio | +/- 1 LSD; LSD displayed - 1/0.1/0.01/0.001 for 1/10/100/1000 cycles averaged |

| | | |
|---|---|---|
| | Time Interval | +/- (timebase error X time interval) +/- A input trigger error* +/- B input trigger error* +/- 1 count per cycle averaged |
| | Event Count | no inherent error; LSD displayed - 1 count |
| CONTROLS | | power; 5 mode selector switches; 4 range selector switches; run; hold; reset; display delay; internal/external timebase switch; plus trigger level, slope select, and attenuator for both A and B inputs |
| DISPLAY | | 8 digit, 7-segment 0.43 inch LED display; decimal point indicates time in microseconds, frequency in kHz; discrete LEDs indicate OVERFLOW (counter overflow) and GATE (gate open); delay feature varies period between measurement cycles from 75 msec to 7.5 seconds with DELAY control, detent position holds next measurement reading indefinitely |
| POWER | | 105-135 VAC, 57-63 Hz, 10 VA maximum (215-230 VAC, 50-60 Hz version available) |
| DIMENSIONS | | 3 x 10 x 7 inches H x W x D (76 x 254 x 178 mm) 3.0 lbs (1.4 kg) |
| OPERATING TEMPERATURE | | 0C to 50C, calibrated at 25C +/- 5C |
| INCLUDES | | instruction manual |

* Note: Trigger error = $\frac{\text{peak-to-peak noise voltage on input}}{\text{signal slope (in volts per second)}}$

## INTRODUCTION

The model 5001 Universal Counter-Timer is designed for the electronic measurement and display of frequency, period, time interval, and counted events. Both input channels feature full and independent signal conditioning by means of attenuation, slope selection, and variable trigger level. The variable delay/hold function allows the introduction of a delay between measurement cycles of from 75 milliseconds to 7.5 seconds, or the results of a single measurement can be displayed indefinitely.

Ease of use combine with rugged design to provide an instrument that will fill a wide range of requirements.

FREQUENCY measurements can be made up to 10 MHz, with a choice of displayed resolution of 100 Hz, 10 Hz, 1 Hz, or 0.1 Hz using the gate times of 0.01 seconds, 0.1 seconds, 1 second, or 10 seconds.

PERIOD measurements are easily accomplished covering the range from 400 nanoseconds to 10 seconds. By selecting 1, 10 100, or 1000 cycle average, a resolution of 100ns, 10ns, 1ns, or 0.1ns is achieved.

The ratio of the frequency at the A input compared to that at the B input is displayed by using the FREQUENCY RATIO mode. The number of cycles averaged will determine the resolution, with up to third decimal place accuracy possible using 1000 cycles.

The TIME INTERVAL mode will measure the elapsed time, from 200 nanoseconds up to 10 seconds, between an edge occurring at the A input and a separate edge at the B input. Either a rising or falling edge can be selected for either input, making this mode useful for measuring not only the time between events, but also for measuring pulse widths.

When the EVENT COUNT mode is selected, the 5001 will display the number of edges, either rising or falling, that appear at the A input. These events can occur at a rate of up to 10 MHz, and the count can be frozen or reset at any time by means of the front panel switches.

Using the rear panel EXTERNAL TIMEBASE INPUT provides capabilities such as extended resolution or automatic scaling beyond that which is normally available using the Frequency Ratio mode. This is, of course, in addition to the ability to connect a high-precision 10 MHz clock source if higher accuracy is required than that of the normal timebase.

The many features and functions of the 5001, combined with the bright 8 digit, 0.43 inch LED display with automatic decimal point placement and separate annunciators for gate-open and counter-overflow conditions, result in a flexibility and ease of use that are appropriate for any counter-timer demands, all in one rugged and reliable instrument.

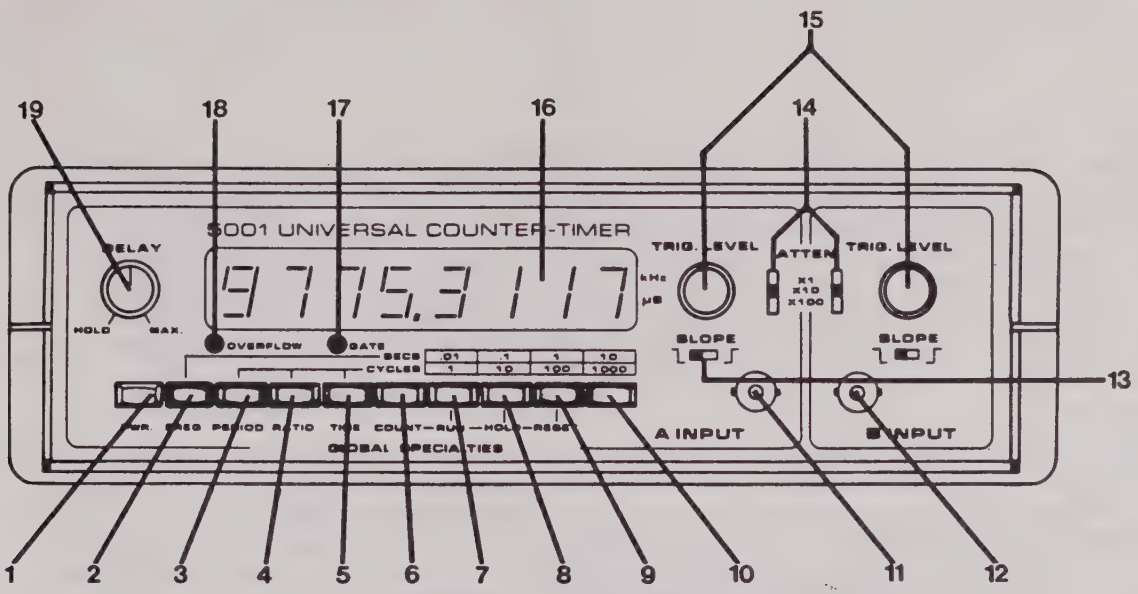


Figure 1 - Control Locations - Front Panel

## CONTROL LOCATIONS AND DESCRIPTIONS

(1) PWR

Power switch. Push in this red pushbutton to turn the unit ON, push again to release to OFF. The display will light, dependent upon the switch settings. If none of the other pushbuttons are pushed in, the display will be blank.

(2) FREQ.

This first gray pushbutton selects the **Frequency Counter** mode of operation. Either the rising or falling edge (as determined by the setting of the SLOPE switch) of the signal applied to the A input will be counted during the gate time selected by the white pushbuttons (either .01, .1, 1, or 10 seconds), and will be displayed in kiloHertz with the appropriate decimal point. The measurement range extends from DC to 10 MHz.

(3) PERIOD

The second gray pushbutton selects the **Period measurement** mode of operation. This measures the time that elapses from one rising edge to the next rising edge, or one falling edge to the next falling edge (as determined by the setting of the SLOPE switch), of the signal applied to the A input. This measurement can be made for a single cycle, or for 10, 100, or 1000 cycles (depending on the white pushbutton selected), giving a resolution of 100ns, 10ns, 1ns, or 0.1ns respectively. The time is displayed in microseconds, with the decimal point automatically positioned. Multiple cycle measurements are displayed as the average value of a single-cycle event. The measurement range extends from 400ns to 10 seconds.

(4) RATIO

The third gray pushbutton selects the **Frequency Ratio** mode of operation. The frequency of the signal present at the A input is

compared to the frequency at the B input, and the ratio of A/B is displayed. This can be accomplished for 1, 10, 100, or 1000 cycles at the B input (as determined by the selection of the white pushbuttons), displaying the ratio with resolutions out to the third decimal place. Either the rising or falling edge can be selected for both the A and B inputs. Input frequencies can range from DC to 10 MHz into the A input, and DC to 2 MHz into the B input.

(5) **TIME**

The fourth gray pushbutton selects the **Time Interval** mode of operation. The amount of time that elapses between a signal edge that occurs at the A input and an edge at the B input is measured, and displayed in microseconds. In essence, the signal at A starts the timer, and the signal at B stops it. Either the rising or falling edge can be selected for both the A and B inputs, and the display can be the average of the result of either 1, 10, 100, or 1000 A-to-B events (as determined by the selection of the white pushbuttons). It is important to note, however, that whereas the resolution will increase when more cycles are averaged, the accuracy of the reading does not. This is due to the inherent +/- 1 count uncertainty, coupled with the fact that the instrument actually takes an entirely new measurement for every A-to-B transition. There is therefore a +/- 1, +/- 10, +/- 100, or +/- 1000 count uncertainty for the 1, 10, 100, and 1000 cycle averages, and absolute reading accuracy does not change. The Time Interval mode is functional over a 200ns to 10 second range.

(6) **COUNT**

The fifth gray pushbutton selects the **Event Counter** mode of operation. The instrument will display the number of rising or falling signal edges (determined by the setting of the SLOPE switch) that occur at the A input. The rate can be up to 10 MHz, and the maximum count displayed before counter overflow is 99,999,999. In the Event Counter mode, the white pushbuttons perform the following functions:

> (7) **RUN.** The first white pushbutton, when pressed in, will allow the 5001 to display, in real time, the number of events that have been counted. If the **RESET** button had been pressed, the display will be cleared, with only the rightmost decimal point lit, when **RUN** is selected. If the **HOLD** button had been pressed in, selecting **RUN** will update the display from the frozen count to the present count and allow real-time display of the count to continue.
>
> (8) **HOLD.** The second white pushbutton provides a "display hold" function. When selected, the instrument will freeze the count on the display, but the running count will continue to accumulate. When the **RUN** button is pressed

in, the display will change immediately to reflect the total count. If the RESET button is pressed, the internal counters will clear to zero, and the display will clear to show only the rightmost decimal point.

**(9) RESET.** The third white pushbutton will reset the internal counters to zero and will clear the display. When pressed in, only the rightmost decimal point will be lit.

**(7) .01/1/RUN**

This first white pushbutton affects the operation of the instrument in the following way:

In the **Frequency Counter** mode, the .01 second gate time is selected.

In the **Period, Frequency Ratio, and Time Interval** modes of operation, the display will reflect the measurement of the signals over a single measurement cycle.

In the **Event Counter** mode, the RUN function is selected; the 5001 will count signal edges and display the total in real time.

**(8) .1/10/HOLD**

The second white pushbutton affects the operation of the instrument in the following way:

In the **Frequency Counter** mode, the 0.1 second gate time is selected.

In the **Period, Frequency Ratio, and Time Interval** modes of operation, the display will reflect the average signal value of a single cycle by measuring ten cycles and dividing the result by ten.

In the **Event Counter** mode, the HOLD function is selected; the 5001 will continue to count signal edges, but the display will not be updated until the RUN button is pressed back in.

**(9( 1/100/RESET**

The third white pushbutton affects the operation of the instrument in the following way:

In the **Frequency Counter** mode, the 1.0 second gate time is selected.

In the **Period, Frequency Ratio, and Time Interval** modes of operation, the display will reflect the average signal value of a single cycle by measuring one hundred cycles and dividing the result by one hundred.

In the **Event Counter** mode, the RESET function is selected; the 5001 will stop counting, the internal counters will clear to zero, and the display will blank, leaving only the rightmost decimal point lit.

**(10) 10/1000**

The fourth white pushbutton affects the operation of the instrument in the following way:

In the **Frequency Counter** mode, the 10 second gate time is selected.

In the **Period, Frequency Ratio, and Time Interval** modes of operation, the display will reflect the average signal value of a single cycle by measuring one thousand cycles and dividing the result by one thousand.

Although it is not marked as such, this button also performs the HOLD function in the **Event Counter** mode.

**(11) A INPUT**

This BNC connector is the input that will be used for all measurements - alone when in the Frequency, Period, and Event Counter modes, and in conjunction with the B input when in the Frequency Ratio and Time Interval modes.

**(12) B INPUT**

This BNC connector will be used for signal inputs only in the Frequency Ratio and Time Interval modes of operation, and then only in conjunction with the A input. There are no circumstances when the B input will be used alone. If the Frequency, Period, or Event Counter modes are selected, any signal present at the B input will be ignored. Under these conditions, it is good practice to disconnect the signals to the B input, but it is not essential to do so.

**(13) SLOPE**

These switches determine the signal edges, either rising or falling, that the 5001 will use in the various measurement modes. The selected edge will be the one that the instrument uses to count, or, in the Time Interval mode, will be the signal that starts or stops the timer.

**(14) ATTEN.**

The ATTENuator controls are used to select the amount of attenuation that the input signals receive before being counted by the 5001. In the X1 position, the full signal is passed to the input stage of the instrument. When X10 is selected, the counter sees a signal that is 1/10th the amplitude of the original, and when in X100, the signal is 1/100th the original. This is useful in obtaining a stable and accurate count, for there is often noise present on a signal, and if the level of the signal is attenuated, so will the noise be.

**(15) TRIG. LEVEL**

The TRIGger LEVEL controls determine the voltage level at which the 5001 will recognize and count the input signal. With the ATTENuator switches in the X1 position, the range of the control extends from -0.5 volts to +0.5 volts. The twelve o'clock position corresponds to a zero volt threshold, one o'clock is +0.1 volts, two o'clock is +0.2 volts, and so on. The eleven o'clock position will set a threshold of -0.1 volts, ten o'clock is -0.2 volts, and so on. When the ATTENuator switch is in the X10 position, the trigger level range is from -5 volts to +5 volts, and when the ATTENuator switch is in the X100 position, the range is from -50 volts to +50 volts. The threshold points continue to roughly correspond to clock

positions. Using the ATTENuator and TRIGger LEVEL controls together will allow a wide range of signals to be measured, such as AC superimposed on DC, logic levels for TTL, ECL, and CMOS, and ringing or noisy digital signals.

**(16) DISPLAY**

The display consists of eight seven-segment LEDs with a 0.43 inch character height. Leading zeros are blanked in all modes, and decimal points automatically display Frequency in kiloHertz, Period and Time Interval in microseconds, and Frequency Ratio and Event Count in units.

**(17) GATE**

The GATE LED lights to indicate that a measurement cycle is in progress. In the Frequency mode, the LED will light for 0.01, 0.1, 1.0, or 10 seconds, depending on the selection of the white pushbuttons. The LED will be off for a time between 75 milliseconds and 7.5 seconds, as determined by the setting of the DELAY control. In the Period and Frequency Ratio modes, the LED will be lit for the duration of 1, 10, 100, or 1000 cycles present at the A input, depending on the setting of the white pushbuttons, and be off for the duration of one cycle at the A input, or the time set by the DELAY control, whichever is longer. In the Time Interval mode, the LED will be lit for 1, 10, 100, or 1000 A-to-B transitions, depending on the setting of the white pushbuttons, and be off for the duration of one A-to-B transition or the time set by the DELAY control, whichever is longer. In the Event Count mode, the LED will be lit continuously; the DELAY control will have no effect.

**(18) OVERFLOW**

The OVERFLOW LED will light whenever the count exceeds 99999999. This will occur, for example, when a frequency over 10 MHz is input and the gate time is 10 seconds, or when a time interval over 10 seconds is measured with 1000 cycles averaged.

**(19) DELAY**

The DELAY control allows the introduction of a time delay between one reading and the next. This delay varies from a maximum of approximately 7.5 seconds when the control is fully clockwise, to a minimum of approximately 75 milliseconds when the control is in the fully counterclockwise - but before the detent - position. When the control is clicked into the detent position, labeled HOLD, the 5001 will take one measurement and display the results indefinitely. This control also serves the function of "priming" the instrument for single cycle events. Further information on the use of this control can be found in the OPERATING INSTRUCTIONS section.

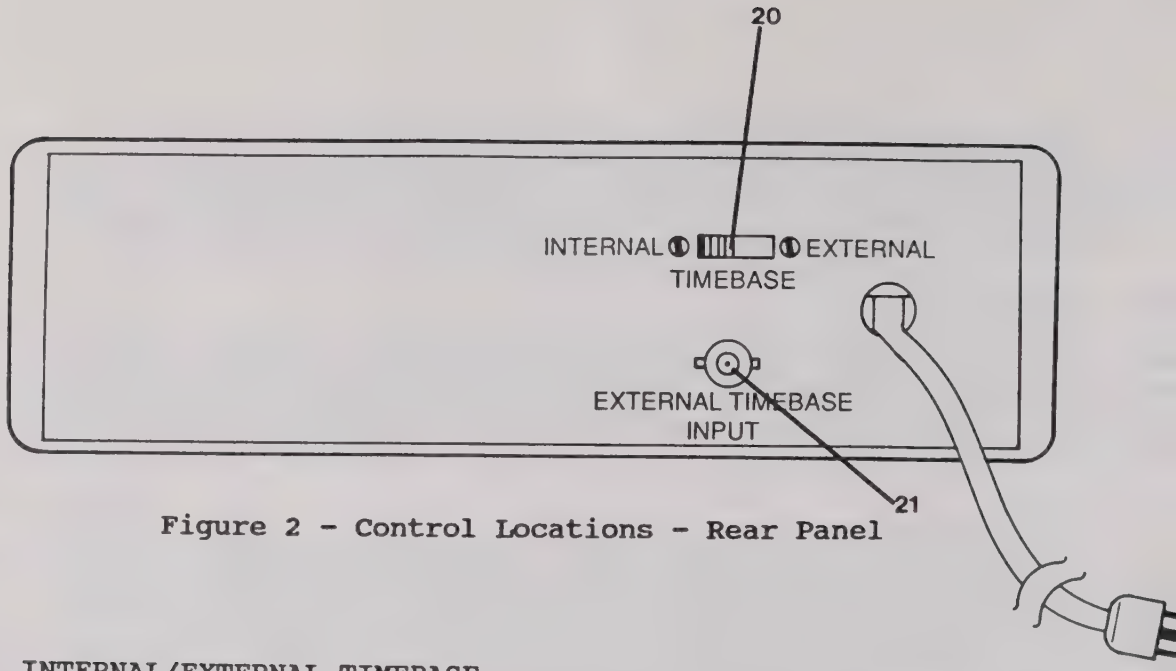


**Figure 2 - Control Locations - Rear Panel**

**(20) INTERNAL/EXTERNAL TIMEBASE**

The INTERNAL/EXTERNAL TIMEBASE switch allows the selection of either the internal 10 MHz reference, or an externally applied reference within a frequency range of 100 kHz to 10 MHz. If no external reference is present on the EXTERNAL TIMEBASE INPUT connector, the switch MUST be in the INTERNAL position for the 5001 to function. Use of an external timebase can provide such added features as increased resolution, greater accuracy, and automatic scaling. Further discussion and examples can be found in the OPERATING INSTRUCTIONS and APPLICATIONS sections.

**(21) EXTERNAL TIMEBASE INPUT**

This BNC connector is used as the input for an external timebase signal. The signal must be TTL level, with a frequency between 100 kHz and 10 MHz, having a minimum pulse width of 50 nanoseconds. If the external timebase is not in use, it is good practice to disconnect any signal present at this BNC, but it is not essential to do so.

## INITIAL INSPECTION AND CHECKOUT PROCEDURE

In order to accomplish the initial inspection of the 5001, the following is required:

1. A grounded (three-prong) 50/60 Hz AC outlet of the correct voltage.
2. A 10 MHz sine wave signal source of 100 millivolt RMS amplitude, no DC offset.
3. A 100 kHz sine wave signal source of 100 millivolt RMS amplitude, no DC offset.
4. A 1 MHz TTL-level signal source.

Note - signal levels for items 2 and 3 above are not critical. However, if different amplitudes are used, the ATTENuator and TRIG LEVEL settings outlined in the following will have to be adjusted accordingly.

PROCEDURE

1. Plug the 5001 into the outlet. Select the Frequency Counter mode and the .01 second gate time (the first white pushbutton). Turn the DELAY control to minimum (fully counterclockwise, but before the detent [HOLD] position). Select the INTERNAL TIMEBASE from the rear panel. Turn power ON - the display should now light, showing .0 on the right.

2. Connect the 10 MHz signal source to the A input. Switch the A input ATTENuator to X1. Set the A input TRIG LEVEL control to the 12 o'clock position - the display should now read 10000.0, indicating the frequency in kiloHertz, and the GATE LED will flash rapidly.

3. Select the .1 second gate time (the second white pushbutton) - the display will change to 10000.00. Note that the GATE LED flashes more slowly, reflecting the longer gate time.

4. Select the 1 second gate time (the third white pushbutton) - the display will change to 10000.000, and when the GATE LED lights it will be on for one second.

5. Select the 10 second gate time (the fourth white pushbutton) - the display will change to 10000.0000. The GATE LED will now stay on for ten seconds as the measurement is being made.

6. Rotate the DELAY control to its full clockwise position - note that the "off" time of the GATE LED (the time between measurements) increases to at least 7.5 seconds. Return the control to its previous (counterclockwise - before the detent) position.

7. Connect the 1 MHz TTL-level signal to the EXTERNAL TIMEBASE INPUT BNC on the rear panel. Switch the INTERNAL/EXTERNAL TIMEBASE switch to the EXTERNAL position. Select the .1 second gate time - the display should now read 100000.00. Note that the GATE LED now lights for 1 second, and the time between measurements is approximately 1.5 seconds. Return the INTERNAL/EXTERNAL TIMEBASE switch to the INTERNAL position and disconnect the signal going to the EXTERNAL TIMEBASE INPUT BNC.

8. Connect the 100 kHz signal to the B input. Switch the B input ATTENuator to the X1 position and set the B input TRIG LEVEL control to the 12 o'clock position. Select the Frequency Ratio mode, 1 cycle average (first white pushbutton). The display should now read 100.

9. Select in order the 10, 100, and 1000 cycle averages (the second, third, and fourth white pushbuttons) - the display will change to read 100.0, 100.00, and 100.000, respectively.

10. Disconnect the signals going to the A and B inputs. Connect the 100 kHz signal to the A input and select the Period mode. The display will read 10.0000 microseconds and the GATE LED will flash rapidly.

11. Select in order the 100, 10, and 1 cycle averages. The display will change to read 10.000, 10.00, and 10.0 microseconds, respectively. The GATE LED will be on too briefly to be seen in the 10 and 1 cycle averages.

12. Select the Event Counter mode. The display will clear and immediately begin to show the accumulating count. The GATE LED will be lit.

13. Press in the HOLD (second white) pushbutton - the display will "freeze", but the 5001 will still be accumulating counts internally. The GATE LED will remain lit.

14. Press in the RUN (first white) pushbutton - the reading will change to update the count, and will show the count accumulating. If the count has been in progress for more than 100 seconds, the OVERFLOW LED will be lit.

15. Press in the RESET (third white) pushbutton - the display will clear, showing only the rightmost decimal point, and the GATE LED will not be lit.

16. Press in the RUN pushbutton - the counting will begin again from zero.

17. Connect the 100 kHz signal to both the A and B inputs simultaneously. Select the Time Interval mode. Switch the A input SLOPE switch to the rising edge (right-hand side) position and the B input SLOPE switch to the falling edge

(left-hand side) position. Set both TRIG LEVEL controls to their 12 o'clock positions. Select 1 cycle average - the display should indicate approximately 5.0 microseconds.

18. Select in order the 10, 100, and 1000 cycle averages. The display will change to read 5.00, 5.000, and 5.0000 microseconds, respectively. Some instability may be noted in the readings as more cycles are averaged; this is normal, as it reflects the +/- 1 count error that exists for each cycle when in the Time Interval mode.

19. Slowly rotate the A input TRIG LEVEL control clockwise - the reading will decrease until the display indicates approximately 3 microseconds, at which point measurements will cease. Rotating the control back counterclockwise will restart the measurements, and the readings will increase to approximately 7 microseconds at which point measurements will again cease. Return the control to the 12 o'clock position.

20. Repeat step 19 using the B input TRIG LEVEL control; the results should be identical.

21. Change the A input SLOPE switch to the falling edge (left-hand side) position and the B input SLOPE switch to the rising edge (right-hand side) position. Repeat steps 19 and 20. The TRIG LEVEL controls will now cause the readings to increase when they are rotated clockwise, and decrease when they are rotated counterclockwise.

This concludes the initial inspection and checkout of the 5001.

NOTE: If no frequency sources are available, a rudimentary test of basic instrument functionability can be accomplished using the built-in SELF-TEST mode, the procedure for which follows. This is by no means a thorough test, but it will verify proper operation of some internal logic and counting functions.

1. With power turned ON, press in both the Frequency and Period mode pushbuttons. Select the .01 second gate time (first white pushbutton), INTERNAL timebase, and minimum DELAY (control fully counterclockwise, but before the detent) - the display will indicate 10000.0 regardless of the setting of the ATTENuator switches, TRIG LEVEL controls, or SLOPE selectors.

2. Rotate the DELAY control to its full clockwise position - note that the "off" time of the GATE LED (the time between measurements) increases to at least 7.5 seconds. Return the control to its previous (counterclockwise - before the detent) position.

3. Select in order the .1, 1, and 10 second gate times. The display will read 10000.00, 10000.000, and 0000.0000 (with the OVERFLOW LED lit), respectively.

This concludes the SELF-TEST checkout procedure.

## OPERATING INSTRUCTIONS

Because of the tremendous functional versatility of the 5001, these instructions will treat each of the features of this instrument individually. There is first presented a description of how to use each of the operating modes, then a discussion of how to adjust the signal conditioning at each of the inputs, followed by a description of the use of the Display Hold/Measurement Cycle Delay feature, and finally the use of the External Timebase Input.

### OPERATING MODES

**Frequency Counter**

To make a frequency measurement:

1. Select the INTERNAL timebase from the rear panel.
2. Turn power ON by pressing in the red PWR pushbutton.
3. Select the Frequency Counter mode by pressing in the FREQ (first gray) pushbutton.
4. Set the DELAY control to minimum (fully counterclockwise, but before the detent).
5. Connect the input signal to be measured to the A input BNC. Follow the Signal Conditioning instructions, below.
6. Select a gate time of .01, .1, 1, or 10 seconds, as desired, to obtain a resolution of 100 Hz, 10 Hz, 1 Hz, or 0.1 Hz, respectively. The display will indicate the frequency in kiloHertz.
7. The GATE LED will be on during measurement cycles and off between measurement cycles. Actual measurement rate is determined by the sum of the GATE time selected, the DELAY time selected, and a fixed amount of display latch "housekeeping" time.
8. The OVERFLOW LED will light in the Frequency Counter mode only when a frequency of 10 MHz or greater is measured using a GATE time of 10 seconds.

**Period**

To make a period measurement:

1. Select the INTERNAL timebase from the rear panel.
2. Turn power ON by pressing in the red PWR pushbutton.
3. Select the Period mode by pressing in the PERIOD (second gray) pushbutton.
4. Set the DELAY control to minimum (fully counterclockwise, but before the detent).
5. Connect the input signal to be measured to the A input BNC. Follow the Signal Conditioning instructions, below.
6. Select whether the measurement will be taken every cycle or averaged over 10, 100, or 1000 cycles. The resulting resolution will be 100 ns, 10 ns, 1 ns, or 0.1 ns, respectively, and the display will indicate the period in microseconds.

7. The GATE LED will be on during measurement cycles and off between measurement cycles. Actual measurement rate is determined by the sum of the total period of the selected number of input signal cycles, the DELAY time selected, and a fixed amount of display latch "housekeeping" time.
8. The OVERFLOW LED will light in the Period mode when the period measured is equal to or greater than 10 seconds, 1 second, 100 milliseconds, or 10 milliseconds for 1, 10, 100, or 1000 cycles averaged, respectively.

**Frequency Ratio**

To make a frequency ratio measurement:

1. Select the INTERNAL timebase from the rear panel.
2. Turn power ON by pressing in the red PWR pushbutton.
3. Select the Frequency Ratio mode by pressing in the RATIO (third gray) pushbutton.
4. Set the DELAY control to minimum (fully counterclockwise, but before the detent).
5. Connect the input signal with the higher frequency to the A input, and the lower frequency signal to the B input. Follow the Signal Conditioning instructions, below. Note - if desired, the higher frequency signal may instead be connected to the B input. This will result in a display of less than 1. Bear in mind that the available resolution is lessened when used in this configuration.
6. Select whether the measurement will be taken every cycle, or averaged over 10, 100, or 1000 cycles. The resulting resolution will be in whole units, or to the first, second, or third decimal place, respectively, and the display will indicate the numerical ratio of the A input frequency divided by the B input frequency.
7. The GATE LED will be on during measurement cycles and off between measurement cycles. Actual measurement rate is determined by the sum of the total period of the selected number of input signal cycles at the B input, the DELAY time selected, and a fixed amount of display latch "housekeeping" time.
8. The OVERFLOW LED will light in Frequency Ratio mode when the ratio measured is equal to or greater than $10^8/1$, $10^7/1$, $10^6/1$, or $10^5/1$ for 1, 10, 100, or 1000 cycles averaged, respectively.

**Time Interval**

To make a time interval measurement:

1. Select the INTERNAL timebase from the rear panel.
2. Turn power ON by pressing in the red PWR pushbutton.
3. Select the Time Interval mode by pressing in the TIME (fourth gray) pushbutton.
4. Set the DELAY control to minimum (fully counterclockwise, but before the detent).

5a. If the elapsed time between two separate events is

to be measured:

1. Connect the signal that is to start the timing sequence to the A input. Determine whether a rising or falling edge is appropriate and set the A input SLOPE switch accordingly.
2. Connect the signal that is to terminate the timing sequence to the B input. Determine whether a rising or falling edge is appropriate and set the B input SLOPE switch accordingly.
3. Follow the Signal Conditioning instructions, below, for proper setting of the controls other than the SLOPE switches.

5b. If the pulse width of a single signal is to be measured:

1. Connect the signal to both the A and B inputs simultaneously.

2a. If the "high" time of the signal is to be measured, set the A input SLOPE switch to the rising (right-hand side) position and the B input SLOPE switch to the falling (left-hand side) position.

2b. If the "low" time of the signal is to be measured, set the A input SLOPE switch to the falling (left-hand side) position and the B input SLOPE switch to the rising (right-hand side) position.

3. Follow the Signal Conditioning instructions, below, for proper setting of the controls other than the SLOPE switches.

6. Select whether the measurement will be taken for every A-to-B transition, or averaged over 10, 100, or 1000 such events. The resulting resolution will be 100 ns, 10 ns, 1 ns, or 0.1 ns, respectively, and the display will indicate the time interval (or pulse width) in microseconds. For single, non-recurring events, set-up the 5001 as follows:

   a. Select 1 cycle average (the first white pushbutton).
   b. Rotate the DELAY control fully counterclockwise to the HOLD (detent) position.
   c. Rotate the DELAY control slightly clockwise until a "click" is heard. This should be the minimum position, before the detent. The GATE LED should now be on. This indicates that the 5001 is "primed", ready to measure and display the first A-to-B transition.

For multiple, recurring events, it is not necessary to "prime" the instrument; simply select the desired number of cycles averaged.

7. The GATE LED will be on during measurement cycles and off between measurement cycles. The measurement cycle begins with the first selected (rising or falling) edge at the A input, and ends with the 1st, 10th, 100th, or 1000th selected edge at the B input.

Actual measurement rate is determined by the sum of the measurement cycle, the DELAY time selected, and a fixed amount of display latch "housekeeping" time.

8. The OVERFLOW LED will light in the Time Interval mode when the interval measured is equal to or greater than 10 seconds, 1 second, 100 milliseconds, or 10 milliseconds for 1, 10, 100, or 1000 cycles averaged, respectively.

**Event Counter**

To count the quantity of a number of events:

1. Select the INTERNAL timebase from the rear panel.
2. Turn power ON by pressing in the red PWR pushbutton.
3. Select the Event Counter mode by pressing in the COUNT (fifth gray) pushbutton.
4. Connect the input signal to be measured to the A input BNC. Follow the Signal Conditioning instructions, below.
5. Press in the RESET (third white) pushbutton. This will clear the display, leaving only the rightmost decimal point lit. This also clears all internal counters to allow the count to begin from zero.
6. When prepared to begin counting events, press in the RUN (first white) pushbutton. The display will follow the running count, that is, the number of selected edges that have appeared at the A input.
7. The OVERFLOW LED will light in the Event Counter mode when the count exceeds 99,999,999. Additional counts will continue to be displayed with the OVERFLOW LED lit.
8. To freeze the display, yet have counts continue to be accumulated internally, press in the HOLD (second white) pushbutton. Pressing in the RUN pushbutton will immediately update the display to the current total of events counted. If the count had exceeded 99,999,999 while in HOLD, the OVERFLOW LED will light when the RUN pushbutton is pressed in.
9. To start a new count, return to step 5.

## SIGNAL CONDITIONING

Extensive signal conditioning on both the A and B inputs is available on the 5001 to ensure maximum flexibility and accuracy. To derive the full benefits of these features, the following guidelines and recommendations are offered:

**Attenuator**

Determine the voltage levels of the signals being applied to the A and B inputs.

- For input signals greater than 2 volts RMS, set the Attenuator to the X100 position.
- For input signals between 0.5 and 2.5 volts RMS, set the Attenuator to the X10 position.
- For input signals less than 1 volt RMS, set the

Attenuator to the X1 position.

Note that the above ranges overlap. Note also that the Trigger Level control range is affected by the Attenuator setting (see below).

The above settings are guidelines only; much depends on the characteristics of the signal being measured. Keep in mind, however, that high-amplitude signals may tend to overload the front-end circuitry of the 5001, especially in the X1 Attenuator position. This will not do any damage (as long as the levels do not exceed the maximums listed in the SPECIFICATIONS), but the instrument may not respond to input signals. As a general rule, the maximum amount of attenuation that can be used - and still allow the 5001 to respond - is the best choice. This will also attenuate any noise that is present on the signal to the extent possible, thus helping to ensure stable and accurate readings.

**Trigger Level**

These controls, one for the A input and one for the B input, determine the voltage level which the input signal must cross for the 5001 to recognize the signal. Used in conjunction with the Attenuator, they allow the measurement of AC signals superimposed on DC, and the point at which digital signals trigger the 5001 internal circuitry. The range of these controls are as follows:

- With the Attenuator in the X1 position: +/- 0.5 volts
- With the Attenuator in the X10 position: +/- 5 volts
- With the Attenuator in the X100 position: +/- 50 volts

Note that problems may arise with AC signals riding on a DC level if that DC level is unstable; these problems can be avoided by placing a capacitor in series with the input signal (between the signal source and the 5001 input). Similarly, a capacitor may also be necessary if the signal to be measured is a comparatively low amplitude riding on a large DC level.

The levels set by these controls roughly correspond to a clock face. For example, with the Attenuator in the X10 position, the 12 o'clock position would set a trigger level of 0 volts, 1 o'clock would set a 1 volt level, 2 o'clock would set a 2 volt level, and so on. Moving counterclockwise, the 11 o'clock position would set a trigger level of -1 volt, 10 o'clock would set a -2 volt level, and so on.

**Slope Selector**

These controls, one each for the A and B inputs, determine whether the rising or falling edges of the input signals will be recognized by the 5001.

- To select the rising edge, slide the Slope switch to the right.
- To select the falling edge, slide the Slope switch to the left.

In the Frequency, Period, and Frequency Ratio modes, the setting of these switches may not seem to matter. However, if one edge of the signal(s) is noisier than the other, best

performance will be realized if the instrument is set to trigger on the "cleaner" edge.
In the Event Counter mode, the selection of the slope will depend on the signal that is to be counted, i.e., if the occurrence of the event is marked by a rising edge, then the Slope switch should be set to the right; conversely, if the event generates a falling, or negative-going, edge, then the Slope switch should be set to the left.
The setting of the Slope switches in the Time Interval mode will depend on the intended use:

- When the elapsed time between separate signals on the A and B inputs is to be measured, the switches must be set to reflect the signals that represent the start and stop times. For example, if a signal with a falling edge is the start signal and a signal with a rising edge is the stop signal, then the A input Slope switch must be set to the falling (left-hand side) position and the B input must be set to the rising (right-hand side) position.
- When the pulse width of a signal applied to the A and B inputs simultaneously is to be measured, the setting of the Slope switches will determine whether the "high" or "low" time is displayed. To measure the time the signal is high, set the A input Slope switch to the rising (right-hand side) position, and the B input Slope switch to the falling (left-hand side) position. To measure the time the signal is low, set the A input Slope switch to the falling (left-hand side) position, and the B input Slope switch to the rising (right-hand side) position.

The following example will help to clarify the use and importance of the signal conditioning controls:

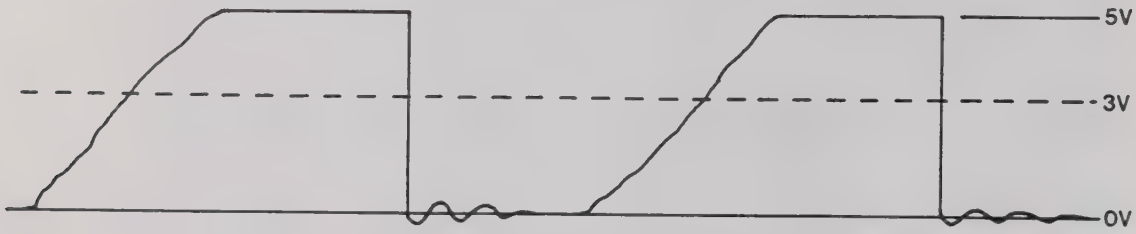


**Figure 3 - Signal Example**

In figure 3, above, it can be seen that the rising edge is slow and noisy, and there is considerable ringing when the voltage goes to zero. Assume that a frequency measurement is desired. In this case, the best point to trigger is on the falling edge at approximately the 3 volt level. This can be accomplished on the 5001 by setting the Attenuator switch to the X10 position, setting the Trigger Level control to the 3 o'clock position, and setting the Slope switch to the falling (left-hand side) position. These settings will allow accurate and stable readings to be easily obtained.

As can be seen, knowing the characteristics of the waveform to be measured greatly simplifies the setting of the signal conditioning controls. If it is not possible to ascertain these characteristics, the best approach would be to start with the maximum amount of attenuation and slowly rotate the Trigger Level control back and forth until a reading is displayed. Decrease the Attenuator setting if necessary. When a reading is obtained, try both positions of the Slope switch to determine which gives the best results.

## DISPLAY HOLD/MEASUREMENT CYCLE DELAY

Under some conditions, the 5001 will make measurements and display them at a rate that is much too fast to read or follow. For this reason, a delay circuit has been incorporated which, at the end of each measurement cycle, delays the start of the next cycle by 0.075 to 7.5 seconds. This delay time is set by the front-panel Delay control. When the control is fully clockwise to the position marked MAX, the delay time is at its maximum; when fully counterclockwise (but before the detent position), the delay will be minimum. During this time, the results of the most recent measurement cycle remain displayed. Initial set-up of the instrument is best accomplished by starting with the minimum delay and rotating the control clockwise until the desired amount of delay is obtained.

The detent position of the Delay control, marked HOLD, permits one measurement cycle to be completed, then delays the start of the next measurement indefinitely. This can be useful for unattended testing, such as measuring the period of a spurious transient event. Another use would be to measure the period of the first pulse generated by an astable oscillator; often the first pulse width or period differs significantly from the pulses following.

Note that, when in the Hold position, changing the mode or the gate time/cycles averaged will initiate a new measurement cycle. Note also that the Delay control has no effect when in the Event Counter mode.

## EXTERNAL TIMEBASE

The External Timebase feature greatly enhances the flexibility of the 5001. By choosing the appropriate timebase, the instrument can be configured to display in non-standard units of measure, increase the measurement accuracy, or extend the measurement ranges in some modes.

> Note: Do not select the External Timebase unless a TTL-level signal in the range of 100 kHz to 10 MHz is present on the External Timebase Input BNC. If no signal is present, the display will not scan, and one digit will be on constantly. Leaving the instrument in this condition will damage the display. Also keep in mind that the display scanning rate

is a function of the timebase frequency; at lower timebase frequencies, and particularly below 500 kHz, the scanning action will be obvious. In addition, the internal "housekeeping" times are also a function of the timebase frequency, so some additional delay between measurement cycles will be noticed.

The external timebase frequency required to allow for the display of different units of measurement can be calculated by means of the following formula:

$$f_{EX} = 10 \times (u_S/u_D)$$

where

$f_{EX}$ = external timebase frequency in MHz
$u_S$ = selected units of measurement
$u_D$ = desired units of measurement

For example, if it is desired to display in cycles per minute when in the Frequency mode in the 1 second gate time:

$$f_{EX} = 10 \times (1/60)$$
$$= .166667 \text{ MHz } (166.667 \text{ kHz})$$

The selection of this timebase frequency will cause the display to indicate in cycles per minute. When the 1 second gate time pushbutton is selected in this case, the actual gate time will be 60 seconds. Note also that the decimal point will still indicate the thousands position, so that if, for example, a 60 Hz signal was applied to the A input with this external timebase, the display would read 3.600.

If an accuracy greater than that which is standard on the 5001 is required, a precision TTL-level signal source can be used as an external timebase. Suitable oscillators are available from a number of sources, some even being phase-locked to WWV signals, giving extreme accuracy.

Extended ranges can be realized using the same reasoning as that described in changing units of measure. In this case, however, decade divisors of 10 MHz are recommended to simplify interpretation of the display. Again, an example will help make this clear:

To achieve the capability of measuring time intervals of up to 1000 seconds before Overflow, use a timebase frequency of 100 kHz. This will allow a time of over 16 minutes to be measured directly in the 1 cycle average position. Note, however, that the resolution will be decreased, in this case to 10 microseconds, and that the position of the decimal point will be unchanged from normal (internal timebase) conditions, and will therefore no longer reflect the normal units.

## Fuse Replacement

The 5001 uses one fuse, type 3AG, 1/4 amp slow-blow (1/8 amp in 230 volt units), 250 volt. It is mounted to a connector on the printed circuit board inside the case, toward the rear, near the power cord (see figure 4, below). If replacement of the fuse becomes necessary, follow this procedure:

1. Disconnect anything plugged into either the A or B input.
2. Make certain the Power switch is OFF.
3. Disconnect the power cord at the AC outlet.
4. Open the case, following the instructions under CASE DISASSEMBLY completely.
5. Use a non-conductive fuse handling tool to safely remove the old fuse, and to replace it with a new one of equal size and rating.
6. Close the case, following the instructions under CASE REASSEMBLY (below) completely.
7. Reattach the power cord to the AC outlet.

The 5001 is again ready for use.

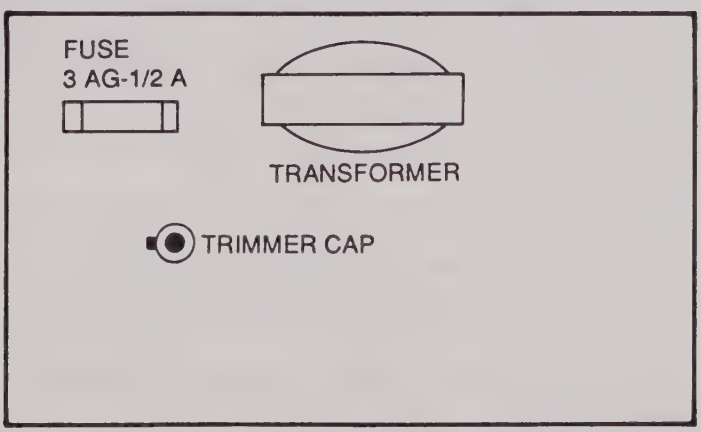


**Figure 4 - Fuse and Trimmer Location**

## Recalibration

The 5001 was calibrated at the factory following a burn-in cycle just previous to shipment; it is warranteed to meet or exceed its published specifications. If at any time the calibration becomes suspect, it is recommended that the instrument be returned to the factory for recalibration to our standards (traceable to the National Bureau of Standards). For details, see FACTORY SERVICE AND REPAIR.

If field recalibration is preferred, the following equipment is required:

- A signal source, preferably 10 MHz, with an output amplitude between 200 millivolts and 2 volts RMS, and an accuracy of 0.4 ppm or better.
- A non-conductive, non-inductive tuning tool.

The procedure is as follows:

1. Remove any connections from both the A and B inputs.
2. Make certain the Power switch is OFF.
3. Disconnect the power cord at the AC outlet.
4. Open the case, following the procedure under CASE DISASSEMBLY completely.
5. Locate the crystal oscillator trimmer capacitor (see figure 4).

**NOTE:**

In the following steps, power will be applied and circuitry will be exposed.

**WARNING**

POTENTIALLY DANGEROUS OR LETHAL VOLTAGES ARE PRESENT WHEN POWER IS APPLIED TO THIS INSTRUMENT WITH CIRCUITRY EXPOSED. USE EXTREME CAUTION. AVOID ALL CONTACT WITH THE CIRCUIT BOARD, EXPOSED COMPONENTS, AND EXPOSED WIRING.

6. Turn on the precision signal source and connect it to the A input of the 5001.
7. Turn the 5001 ON by pressing in the Power pushbutton.
8. Select the Frequency Counter mode by pressing in the FREQ (first white) pushbutton.
9. Set the Delay control to minimum (fully counterclockwise, but before the detent).
10. Select a gate time of .01 seconds.
11. Allow both the signal source and the 5001 to operate at least one hour.
12. Observe the display on the 5001; if it reads 9999.9 or 10000.0 or 10000.1, proceed to step 15.
13. Adjust the Attenuator, Slope, and Trigger Level controls (see OPERATING INSTRUCTIONS) for a stable reading. If the display now reads 9999.9, 10000.0, or 10000.1, proceed to step 15.
14. Using the tuning tool, adjust the trimmer capacitor until the display reads 10000.0.
15. Select a gate time of .1 seconds.
16. Observe the display on the 5001; if it reads 9999.99, 10000.00, or 10000.01, proceed to step 18.
17. Use the tuning tool to adjust the trimmer capacitor for a display of 10000.00.
18. Select a gate time of 1.0 seconds.
19. Observe the display on the 5001; if it reads 9999.999, 10000.000, or 10000.001, proceed to step 21.
20. Use the tuning tool to adjust the trimmer capacitor for a display of 10000.000.
21. Select a gate time of 10 seconds.
22. If the display on the 5001 reads 0000.0000 with the OVERFLOW LED lit, or flickers between this reading and 0000.0001 with the OVERFLOW LED lit, or flickers between 0000.0000 with the OVERFLOW LED lit and 9999.9999 with the OVERFLOW LED not lit, proceed to step 24.
23. Use the tuning tool to adjust the trimmer capacitor for a display of 0000.0000 with the OVERFLOW LED lit.

24. Wait one hour; if the display has not changed, continue to step 25. If the display has changed, return to step 23.
25. Turn power on the 5001 OFF. Disconnect the power cord from the AC outlet. Disconnect the signal source from the A input. Follow the procedure under CASE REASSEMBLY completely.

This concludes the recalibration procedure.

## CASE DISASSEMBLY

1. Disconnect all input cables.
2. Disconnect the power cord from the AC outlet.
3. Turn the 5001 upside-down on a soft or padded surface.
4. Remove the stick-on rubber feet from the foot assemblies. Place them aside, non-sticky side down.
5. Remove the Phillips-head screw from each of the four foot assemblies.
6. Remove the foot assemblies and the flip-up leg.
7. Holding the top and bottom case halves together, carefully turn the case upright.
8. Gently slide the top half of the case straight upward until it is clear or the unit. The PC board will now be visible.
9. If necessary, the PC board can be taken out of the bottom case half by removing the self-tapping screw from the center of the PC board, and lifting the PC board, front panel, and rear panel straight upward from the case as a unit. Note that the front panel, display board, and rear panel remain wired to the main PC board.

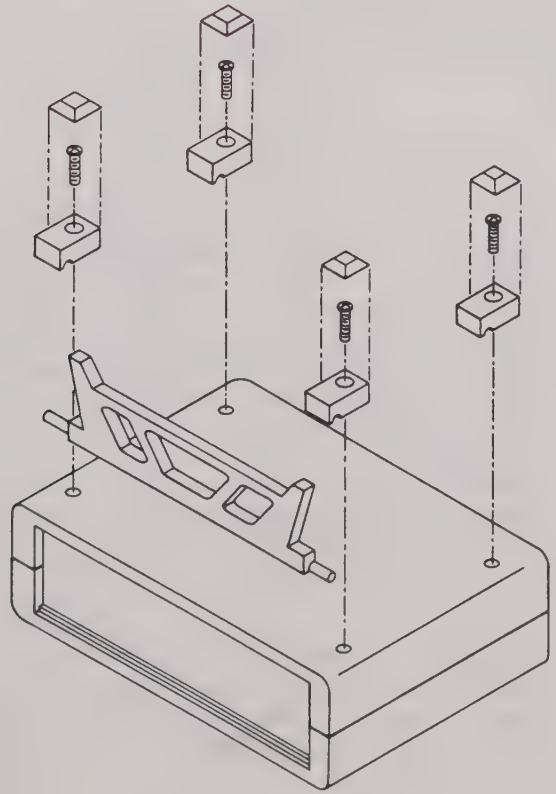

Figure 5 - Case Disassembly/Reassembly

## CASE REASSEMBLY - see figure 5

1. Ensure that no tools remain within the case, and that both upper and lower case halves are clean and free of debris. Remove all power and input connections.
2. If the unit has been removed from the lower case half, replace it as follows: Align the front panel over the switch assembly on the main PC board and, as a unit, slide the front and rear panels into the appropriate grooves (the front of the case is the beveled side) in the bottom half of the case, while allowing the main PC board to drop into the case. Replace the self-tapping screw into the center of the board, being sure that the holes in the four corners of the board are aligned over the holes in the corresponding bosses before tightening this screw.
3. Gently slide the top case half straight down into position atop the bottom case half, making sure that the top and bottom beveled sides face the front and that the front and rear panels are fitting properly in the case panel grooves.
4. While holding the top and bottom case halves together, carefully turn the unit upside-down.
5. Position the flip-up leg and the foot assemblies. The flip-up leg assembly should be to the front, and the leg should fold rearward.
6. Replace the Phillips-head screw in each foot assembly. Take care not to overtighten.
7. Replace the stick-on rubber feet.
8. Return the 5001 to the upright position.

The 5001 is once again ready for use.

## FUNCTIONAL DESCRIPTION

The heart of the model 5001 Universal Counter-Timer is a fully integrated LSI Universal Counter/LED Display Driver circuit, the Intersil ICM7226. Global Specialties has increased the utility of this extremely capable IC with the addition of a number of support circuits and features, as well as handsome packaging in a full-featured professional instrument.

The ICM7226 has been designed to measure frequency, period, frequency ratio, and time intervals, and can also measure the accumulation of events. With a 10 MHz crystal oscillator, resolution in the nanosecond and fractional Hertz range is achievable. Gating, reset, hold, and storage signals are available to increase operational flexibility.

The 5001 provides identical input signal processing on both inputs to fully condition signals for optimum operation of the ICM7226. Selectable attenuation, slope selection, overload protection, trigger level/DC offset adjustment, and buffering are incorporated in both channels. Both input preamplifiers are designed to handle signal frequencies up to 35 MHz; limitations of the ICM7226, however, restrict operation to 10 MHz in the A channel, 2 MHz in the B channel.

The mode, function, and range control switch matrix, in addition to formatting the operation of the ICM7226, provides for automatic clearing and resetting of the counters and the Display Hold/Measurement Cycle Delay timer whenever the selected mode or range is changed. This also occurs when power is first turned on.

The Display Hold/Measurement Cycle Delay timer provides a user-variable delay in the ICM7226 Reset output before it reaches the IC's Hold input.

The eight 0.43 inch, seven-segment LEDs, along with the discrete Overflow and Gate LEDs, are driven by discrete transistors to permit higher drive currents, and therefore higher brightness.

Four separate voltage regulators are used in the 5001 power supply to assure optimum isolation between the digital circuitry and the analog stages of input amplification.

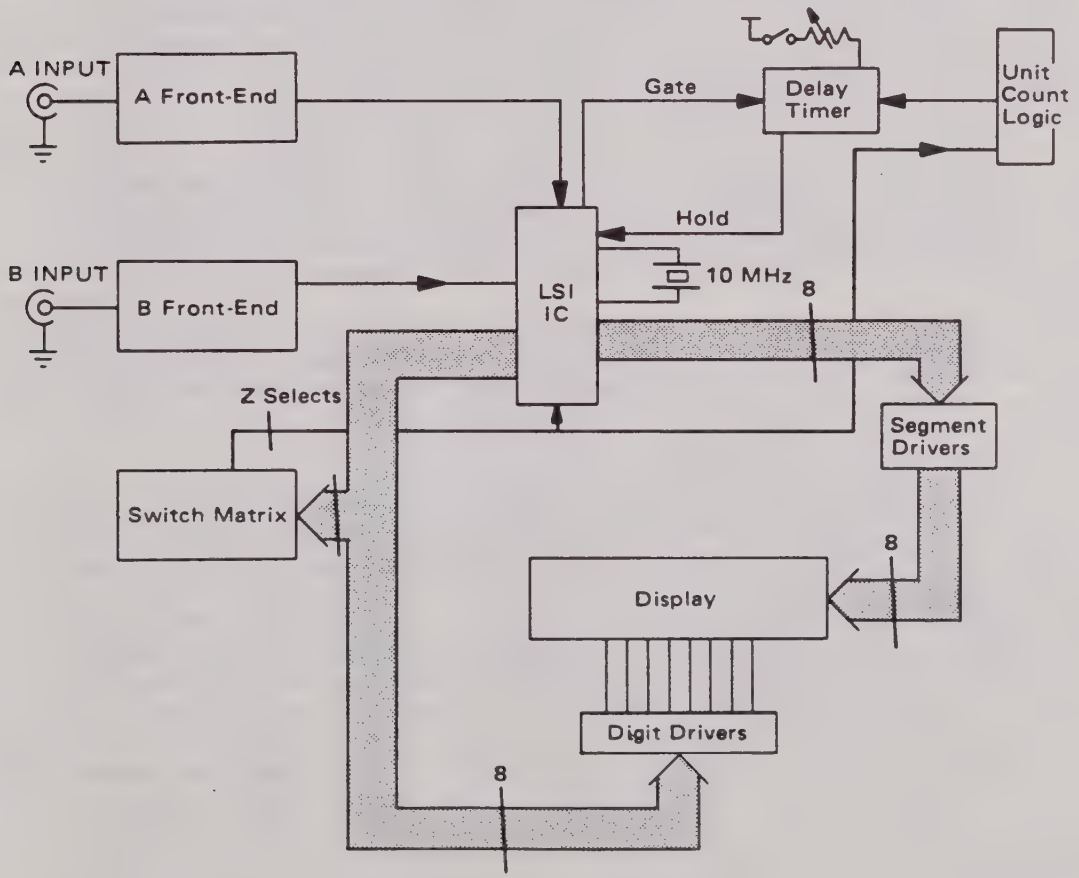


Figure 6 - Block Diagram

## CIRCUIT DESCRIPTION

Refer to the block diagram (figure 6) and the schematic diagram of the 5001 during this discussion of circuit operation.

Input signals at the A and B inputs are connected directly to three position X1/X10/X100 attenuators (R1/C1, R2/C42, R3/C43, and S13 at A; R21/C10, R22/C44, R23/C45, and S14 at B). Input protection is provided by 100 ohm series resistors (R7, R24) and diodes D5-8.

Signals are then buffered and amplified by high-impedance JFET-input compound-series feedback amplifiers (Q1 and Q2 for the A input, Q3 and Q4 for the B input). Biasing for these amplifiers is adjusted by R11 and R30.

Signals then reach high-speed comparators U3 and U8, where they are compared to levels set by Trigger Level controls R5 and R72, which are buffered by op-amp U7 configured as voltage followers. Hysteresis is introduced into the comparators to assure clean switching action even in the presence of slow or noisy input signals.

Exclusive-OR gates (U2) in conjunction with Slope switches S11 and S12 determine whether rising or falling edges will be counted.

Note that the entire preamplifier circuit for both preamplifiers is designed to work with signal frequencies up to 35 MHz; internal limitations of the LSI counter IC, however, limit A channel response to 10 MHz and B channel response to 2 MHz.

All counting, gating, housekeeping, and display drive signal tasks are accomplished by U1, an Intersil ICM7226. A detailed description of its function is beyond the scope of this manual, but a brief summation of its use within the 5001 follows.

A measurement in progress output at pin 2 turns on the Gate Open LED (D20) through transistor Q5.

Function, range, and control inputs are time-multiplexed onto the digit display drive lines. Selector pushbutton switchbank S2 through S10 routes appropriate codes to U1 through contacts in the "A" bank.

For Frequency, Period, Frequency Ratio, and Time Interval, the "B" bank of mode selectors S2 through S6 send a signal to transistor Q17 any time a new mode is selected. This is ORed with a power-up reset signal generated by exclusive-OR gate U2 to initiate a reset for U1 and Delay timer U5. This same function is accomplished slightly differently in the Event Counter mode. Here, the base of Q17 is not grounded directly through the "B" switchbank as it is in the other modes, but is instead grounded through the base-emitter junction of Q8; the emitter of Q8 is connected to ground in every case except when the Reset pushbutton is selected in the Event Counter mode. In this case, the emitter is disconnected and Q17 can turn on to accomplish a reset sequence. When Hold is selected, the base-emitter junction of Q7 is shorted, allowing Q8 to turn on. This activates Delay timer U5, which will keep U1 from updating the display but will not affect the counting function and will not reset the counters. Selecting Run will release the short on the base of Q7, allowing

it to turn on, thereby turning off Q8, releasing the Delay timer, and allowing U1 to update the display and continue counting.

Delay timer U5 is a 555 timer configured as a monostable multivibrator. It drives the Hold input of U1, stopping any measurement in progress, resetting the main counter and making the chip ready to initiate a new measurement. Also, the main counter data latches are not updated, so the display continues to show the last complete measurement. However, because the input to U5 is the Reset output of U1, U5 permits one complete measurement cycle (only) before imposing the Hold condition. U2 buffers the Reset signal from U1. R45 and C22 act as a differentiator, and also allow the ORing of the signals from the collector of Q8. Delay control R73, a logarithmic potentiometer, varies the monostable pulse width at the output of U5 from 75 milliseconds to 7.5 seconds; switch S15 extends it indefinitely.

Switch S15 also performs the "priming" function necessary for the measurement of single, non-repetitive signals. When S15 is opened, as occurs when the Delay control is rotated out of the Hold position, a narrow pulse is generated by the network made up of D26, R14, R48, R47, C23, and C21. This pulse is buffered by U6, which then drives half of U4, a 74123 monostable multivibrator. One output of this half is coupled, through another section of U6, to the A input of U1. The complementary output of the first half of U4 is used to trigger the second half; an output of the second half is coupled, again through a section of U6, to the B input of U6. The end result of this is to provide an A-to-B transition, which readies U1 for a single measurement.

Transistors Q18 through Q25 buffer both digit and segment display drive lines, permitting higher driving currents for optimum display brightness. The Overflow LED (D11) is multiplexed in place of the most significant digit's decimal point.

The power supply makes liberal use of three-terminal regulators. Note that there are separate regulators for the analog and digital sections of the instrument; this helps to ensure maximum isolation between the stages. Regulators A4 and A3 provide +10 volts and -10 volts, respectively, which are used only for comparators U3 and U8. Regulator A1 supplies +5 volts for the input preamplification sections. Regulator A2 generates the +5 volt supply used in all of the remaining digital circuitry.

A input of the 5001. Proceed as detailed under the Operating Instructions section.

## APPLICATIONS

### Frequency Counter

Always measure oscillator frequencies after at least one stage of buffering; measurements taken at the oscillator components themselves can pull the oscillator off-frequency. When this is unavoidable, using a X10 oscilloscope probe connected to the A input of the 5001 will minimize circuit loading, reducing this frequency shift. Keep in mind, however, that a X10 probe will reduce the signal amplitude to the input of the 5001 by a factor of 10, thus reducing the apparent sensitivity; signals of less than 200 millivolts RMS amplitude may not be measurable. In addition, the Trigger Level control will behave as though the attenuator was switched into the next higher range of attenuation.

Certain critical applications may require that the 5001 input impedance be identical to circuit impedance; for example, a 50, 75, or 300 ohm termination may be required to properly load the circuit under test. Since both the A and B inputs are high impedance, this termination may be applied at the 5001 input directly.

When measuring transmitter and other radiated field frequencies, a short piece of wire or telescopic antenna connected directly to the 5001 input may provide adequate coupling for a reliable reading. **DO NOT ATTEMPT TO CONNECT THE 5001 INPUT IN PLACE OF THE TRANSMITTER ANTENNA OR ANYWHERE DIRECTLY IN THE TRANSMISSION LINE.**

To measure a frequency that is only available for a short time, set the Delay control to its Hold (detent, fully counterclockwise) position, press in the Frequency pushbutton and select a gate time of .1, 1, or 10 (but not .01) seconds. Disregard the display at this point. As soon as the signal is available, press in the .01 second gate time pushbutton. The signal then only need remain valid for 10 milliseconds; the instrument will complete one measurement cycle in that time and will display the results of that measurement until the gate time is changed, the mode is changed, or the Delay control is taken out of the Hold position.

For fast, accurate measurements of low frequencies, use the Period mode and calculate the frequency as the reciprocal of period, i.e.,

frequency (in MHz) = 1/period (in microseconds)

See the Period Measurement section, below, for a further discussion of the Period function.

**Frequency Counter example - measuring microprocessor clock frequency:** Locate the microprocessor's buffered clock output. Assuming the signal is at TTL levels, set the A input Attenuator to X10, set the Trigger Level control to 1.5 volts (approximately the 1:30 position), and connect clock and ground directly to the

## Period Measurement

The accuracy of this measurement is very dependent upon the amount of noise present on the input signal; display instability may be observed even when this noise is below the 5001's noise threshold. To substantially reduce this effect, take the average over a larger number of cycles, increase the input amplitude of the waveform, and/or select the steeper edge of the waveform as the triggering edge.

Period measurements yield much quicker and more accurate results than frequency measurements for low frequency phenomena. For example, it would take 10 seconds to provide 0.1 Hz resolution in determining the frequency of a 110.4 Hz (0.1104 kHz) signal in the Frequency Counter mode; in the Period mode, a 100 cycle average of 9057.971 microseconds is available in less than one second. If the period were instead to be measured as 9057.946 microseconds, the frequency could be calculated as 110.4003 Hz, yielding an additional three accurate digits.

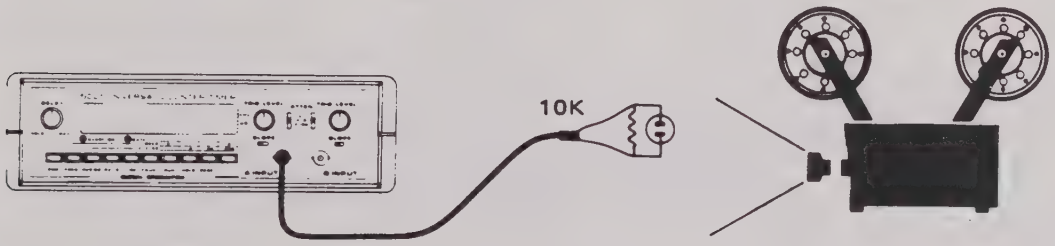


**Figure 7 - Period Application**

**Period Measurement example - measuring the speed of a motion picture (movie) projector:** Like many phenomena, the speed of a motion picture projector may be measured indirectly using the 5001 more simply, more conveniently, and more accurately than through direct measurements of mechanical motion. In the case of a motion picture projector, the variable of interest is frame rate in frames per second. Nominally, most projectors run at either 16 or 24 frames per second; in television film chains, every fifth frame is projected twice, converting nominal 24 frame per second motion pictures to standard 30 frame per second video rates. Accurate framing of video picture information within sync requires that projector speeds be especially accurate. The 5001 permits accurate measurement of these low frequencies through reciprocal calculation of period, as measured by leading edges of photosensitive transducer outputs in response to each projected frame. (see figure 7) A photovoltaic cell may be connected directly to the 5001 input, but response of these is usually slower than that of other photodetectors. A photodiode or phototransistor can be used, but some signal conditioning will be necessary; an example of an appropriate signal conditioning circuit is shown in figure 9.

With no film in the projector, and both motor and light turned on, place the sensor directly in front of the lens. The frame rate can now be calculated by taking the reciprocal of the displayed period. Some degree of optical filtering, limiting, of shadowing may be necessary, depending on the specifics of the detector being used.

**Time Interval**

Unlike other measurement modes that utilize multiple cycle averaging, multiple Time Interval averaged measurements accumulate the total errors occurring in each cycle; this implies both that some jitter is inevitable when averaging multiple intervals - increasing with the averaged number of intervals - and that variance between single interval measurements is to be expected.

The Time Interval mode provides a highly useful facility for determining pulse parameters. This is done by externally commoning the A and B inputs so that the input signal will be applied to both inputs simultaneously. Pulse width (the "high" time) can then be determined by selecting the rising edge on the A input Slope selector and the falling edge on the B input Slope selector. Pulse spacing (the "low" time) can be determined by selecting the falling edge on the A input Slope selector and the rising edge on the B input Slope selector. Pulse period can be determined by taking the sum of the pulse width and pulse spacing, or by selecting the Period mode of the 5001. Pulse repetition rate can be determined by taking the reciprocal of the pulse period, or by selecting the Frequency Counter mode of the 5001. Duty cycle can be determined mathematically. The following formulae apply:

Period = Width + Spacing

Duty Cycle = (Width/Spacing) X 100
= (Width/(Width + Spacing)) X 100
= Width X Frequency X 100

Repetition Rate = Pulse Frequency
= 1/Period
= 1/(Width + Spacing)

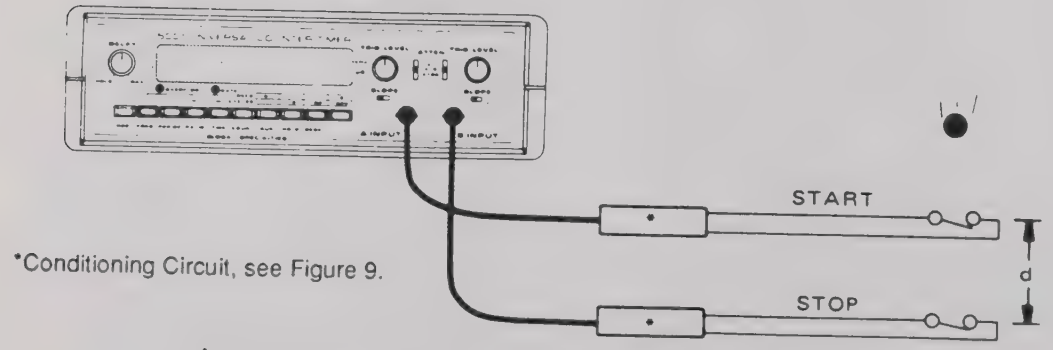


**Figure 8 - Time Interval Application**

**Time Interval example - measuring the time of flight and time of fall for ballistic projectiles or falling objects:** Time of flight and time of fall may be directly measured by the 5001.

The Display Hold feature is especially useful in this case because it always permits one and only one measurement cycle, which cannot begin until the appearance of the selected edge at the A input in the Time Interval mode; once the measurement cycle is completed with the appearance of the selected edge at the B input, the display is held indefinitely. Arranging electrical contacts directly in the path of the object is the simplest means of providing appropriate input signals to the 5001, and is acceptable if the force associated with the mass and velocity of the object is large compared to the contact breaking (or making) force required. Note that by using contact opening as the significant event, errors due to contact bounce problems are avoided. Alternatively, photoelectric beam-break detectors may be used, or other methods more convenient to the specific test. Once clean input signals are available, the measurement can be taken 10, 100, or 1000 times using multiple cycle averaging; beware, however, of contact bounce when switches are restored to their resting position between measurements.

## Frequency Ratio

In many cases, the 5001 will be used in conjunction with a signal derived from the metering of a physical phenomenon, such as rotational speed, flow, linear speed, or weight. The 5001 can be configured to display measurements in terms of the actual units of interest (for example, RPM, gallons per minute, furlongs per fortnight) by taking advantage of the scaling (also called rescaling) capabilities of the 5001 in the Frequency Ratio mode. In this mode, the instrument indicates how many signal edges appear at the A input during the selected number of edges at the B input. In other words, the B input signal "gates" the A input signal. Therefore, instead of displaying frequency measurements in cycles per second (Hertz), they are in cycles per B signal period.

The frequency to apply to the B input can be determined as follows:

1. Determine how many pulses occur per event of interest and convert into the units ultimately desired for the 5001 display. For example, if the number of pulses delivered per pint are known, multiply by 16 to convert to pulses per gallon.

2. Express 1 second in terms of the time units desired. For example, 1/60 minute, 1000 milliseconds, 1/3600 hour.

3. Calculate the frequency needed at the B input as follows:

   Frequency at B = (pulses per event) X (time units in seconds)

4. Using a frequency source, such as the Global Specialties model 4001 Pulse Generator or the model 2002 Function Generator, provide the appropriate signal frequency to the B input. Note that the B input cannot accept a frequency greater than 2 MHz.

**Frequency Ratio example - motor RPM display:** If an encoding disk on a motor shaft gives 1024 pulses per revolution and the motor is rotating at one revolution per second, the 5001 will display a 1.024 kHz reading in the Frequency mode. To convert this to RPM using the Frequency Ratio mode, divide the encoding disk output frequency by 60 (1.024 kHz/60 = 0.01707 kHz = 17.07 Hz). Using this frequency as the B input and selecting the Frequency Ratio mode will yield a display of RPM, in this case 60. Note that the B input frequency must be from a separate source from the A input, and not simply a divided result of the A input, or else a change in the A input frequency will cause a change in the B input frequency, and the ratio (and therefore the display) will remain unchanged.

## Event Counter

As in other modes of operation, the flexibility of the 5001 input circuitry permits a great many devices to be used as sensors, requiring only very simple interface circuitry (the inputs respond only to voltages, so simple contact closures and impedance changes require some conditioning with external circuitry) (see figure 9).

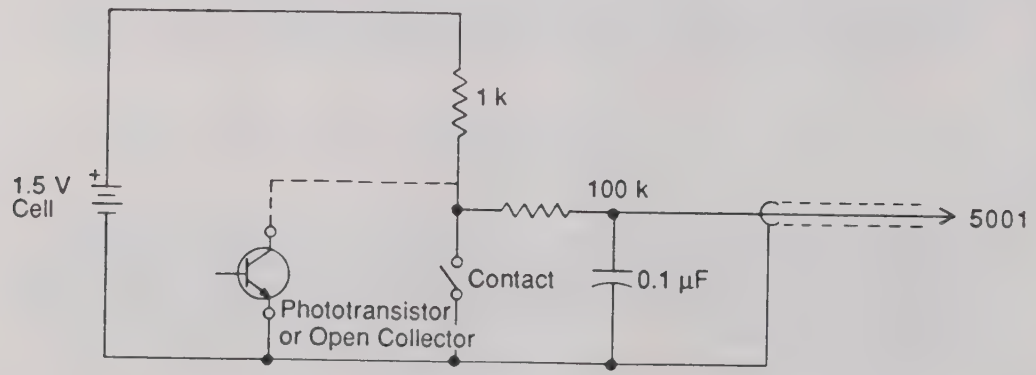


**Figure 9 - Signal Conditioning Circuit**

Additional conditioning of input signals may be required to get accurate counts if the signals include glitches, contact bounce, or a great deal of noise. The circuitry needed may be as simple as an RC filter at the 5001 inputs, or as involved as a monostable multivibrator triggered by the signal; the amount of conditioning necessary will depend on the characteristics of the

signal. The circuit of figure 9 is presented as one example of a signal conditioning scheme. In the case of purely electronic signals, such as error signals generated from a microprocessor, no signal conditioning should be required at all.

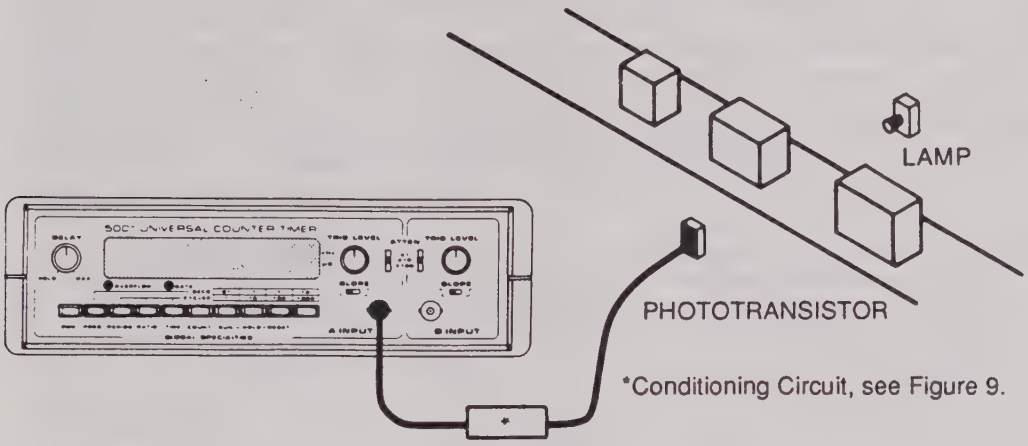


**Figure 10 - Event Counter Application**

**Event Counter example - counting items on a conveyor belt:** A simple photoelectric beam break arrangement provides a suitable input for the 5001. (see figure 10). Assuming each item on the conveyor breaks the beam once and only once, the 5001 can keep a running count on production.

## External Timebase

By using the external timebase capabilities, a variety of useful effects can be realized. The most obvious enhancement that is possible is increased accuracy in the Frequency, Period, and Time Interval modes (the External Timebase has no effect in the Frequency Ratio or Event Counter modes). Other uses include the ability to extend period and time interval measurements up to 1000 seconds or to scale the reading to be units other than seconds, and to perform ratio-type measurements at frequencies above that possible in the Frequency Ratio mode. Note that the signal applied to the External Timebase input must be at TTL levels. If no signal is present at the input, DO NOT switch into the External Timebase mode - damage to the display could result.

**External Timebase examples - extended period measurement:** When using the 5001 with the internal timebase, period measurements of frequencies less than 0.1 Hz cause counter

overflow, resulting in uncertainty as to the final result. Consider the case where a 0.01667 Hz signal is to be measured. Using the internal timebase, a display of 9988002.4 microseconds with the Overflow LED lit would result. If a 1 MHz external timebase is used instead, the most significant digit would not be lost, giving a reading of 5998800.2 with no Overflow indication. Note that the decimal point does not now show the microsecond position; the interpretation of the display must be made bearing in mind the difference between the internal and external timebase frequencies. In this example, the external timebase frequency is 1/10 that of the internal timebase, so the reading must be multiplied by 10, yielding a period of 59988002 microseconds, or 59.988002 seconds.

**Scaling example:** Consider the time interval example of figure 8; if the contacts were placed one meter apart, the 5001 would display the elapsed time for an object traveling one meter. If it was desired instead to measure the time required to travel one foot, one way to accomplish this would be to supply an appropriate external timebase. As one foot = 0.3048 meters, the use of an external timebase of 3.048 MHz (0.3048 X 10 MHz) would result in the direct display in the desired units without moving the contacts or resorting to calculations for each measurement.

**High-frequency ratio example:** In the Frequency Ratio mode, frequencies above 2 MHz cannot be used at the B input. This is not normally a serious limitation, but there could be occasions where higher frequency capabilities would be useful. The External Timebase feature can be used to implement this function. As an example, to compare two oscillators running at a nominal 3.579545 MHz, use one of the oscillators as the external timebase and feed the other oscillator into the A input. Selecting the Frequency Counter mode with a gate time of .01 seconds, a reading of 10000.0 would indicate an exact match. A display of 9999.8 would indicate that the signal present at the A input is 0.002% lower than the external timebase frequency.

# SERVICE AND WARRANTY INFORMATION

## FACTORY SERVICE AND REPAIR

Global Specialties will service and repair this instrument free of charge for a period of one full year, subject to the warranty conditions below.

To obtain a return merchandise authorization (RMA) required for all returns, phone our Customer Service Department for an RMA and all shipping instructions: Tel. 800-572-1028
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DOWNSVIEW, ONTARIO M3J 2S2
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## WARRANTY

Global Specialties warrants this device to be free from defective material or workmanship for a period of one full year from date of original purchase.

Global Specialties under this warranty is limited to repairing the defective device when returned to the factory, shipping charges prepaid, within one full year from date of original purchase.

Units returned to Global Specialties that have been subject to abuse, misuse, damage or accident, or have been connected, installed or adjusted contrary to the instructions furnished by Global Specialties, or that have been repaired by unauthorized persons will not be covered by this warranty.

Global Specialties reserves the right to discontinue models, change specifications, price or design of this device at any time without notice and without incurring any obligation whatsoever.

The purchaser agrees to assume all liabilities for any damages and/or bodily injury which may result from the use or misuse of this device by the purchaser, his employees, or agents.

This warranty is in lieu of all other representations or warranties expressed or implied and no agent or representative of Global Specialties is authorized to assume any other obligation in connection with the sale and purchase of this device.

## BREADBOARDING SOCKETS LIFETIME GUARANTEE

All Global breadboarding sockets are guaranteed for life. If a socket ever fails to meet your requirements, return it and we will replace it, NO QUESTIONS ASKED.

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# CERTIFICATE OF CALIBRATION

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RMA#

MODEL# 5001 SERIAL #

Global Specialties Corporation does hereby certify the above listed instrument meets or exceeds manufacturer's published specifications and has been calibrated using standards which are traceable to The National Bureau of Standards within the limitations of the Bureau's calibration service, or have been derived from accepted values of natural physical constants, or have been derived by the ratio of self-calibration techniques.

STANDARDS: TEKTRONIX 475 OSCILLOSCOPE SR 1953
BECKMAN TECH 310 DVM SR 10910339
WAVETECK SIGNAL GENERATOR SR 329058
GLOBAL SPECIALTIES 2001 FUNCTION GENERATOR SR 151372
GLOBAL SPECIALTIES 4001 PULSE GENERATOR SR 147072
50 UL TERMINATOR
VECTRON 10MHZ TRUETIME & GLOBAL SPECIALTIES 4401 SR 00736

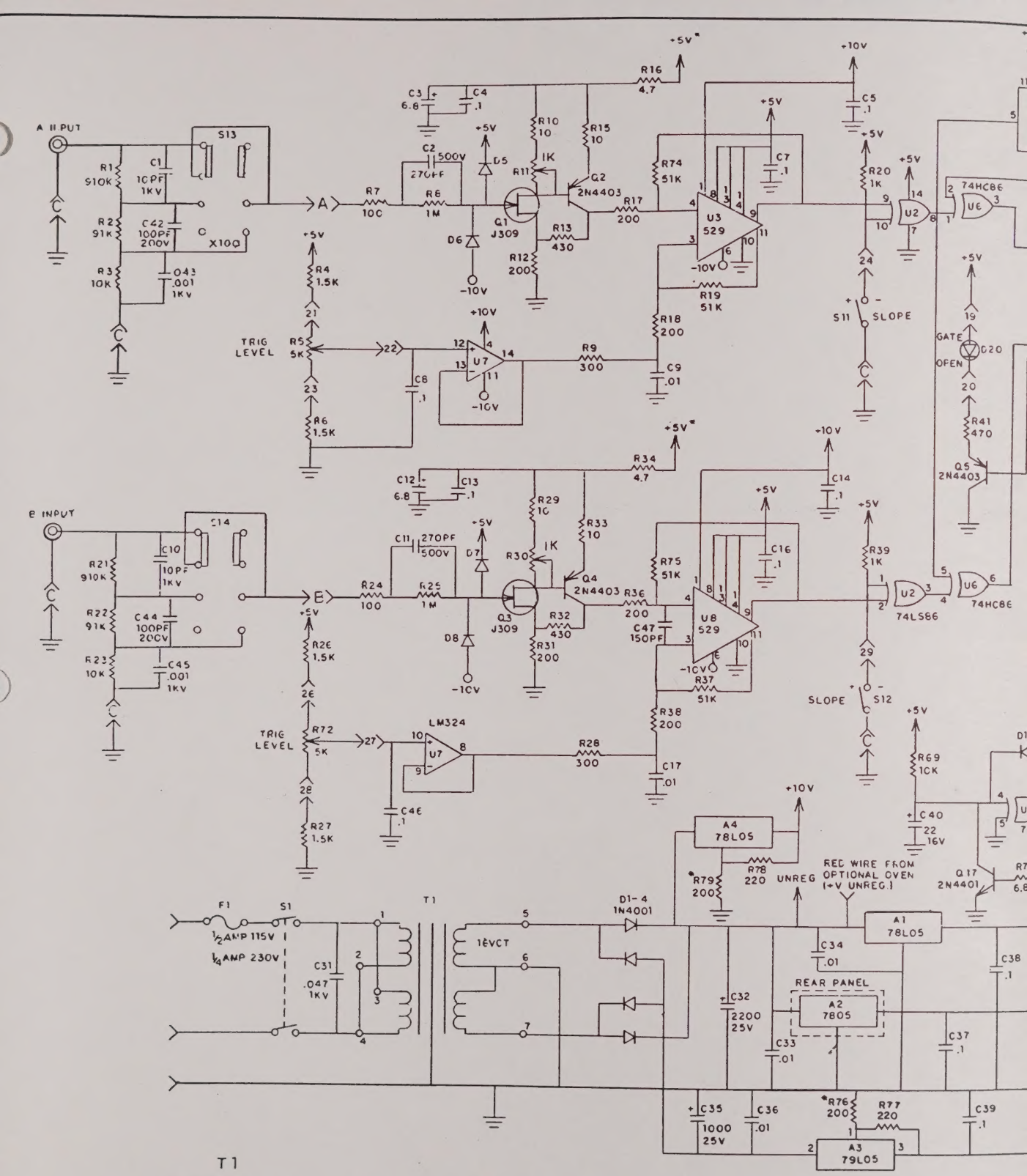
APPLICABLE NBS TEST REPORT NUMBERS:

| | |
|---|---|
| DC Voltage | 216868 |
| AC Voltage | 807675 |
| Resistance | 214691 |
| Temperature | 211875 |
| Frequency | WWVB VLF Transmission |

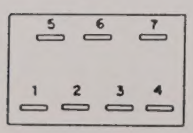
DATE JUNE 15, 1990

CERTIFIED BY

Sandra Gastaldi




T1




FOR 115V CONNECT
1-3 AND 2-4

FOR 230V CONNECT
2-3

41-01-0016 FOR 5001-A
41-01-0028 FOR 5001-A W/OVEN

2N2222 MAY BE SUBSTITUTED FOR 2N4401 PER ECN 961

NOTE:

ALL UNMARKED RESISTORS ¼ WATT, 5%

ALL UNMARKED DIODES 1N4148

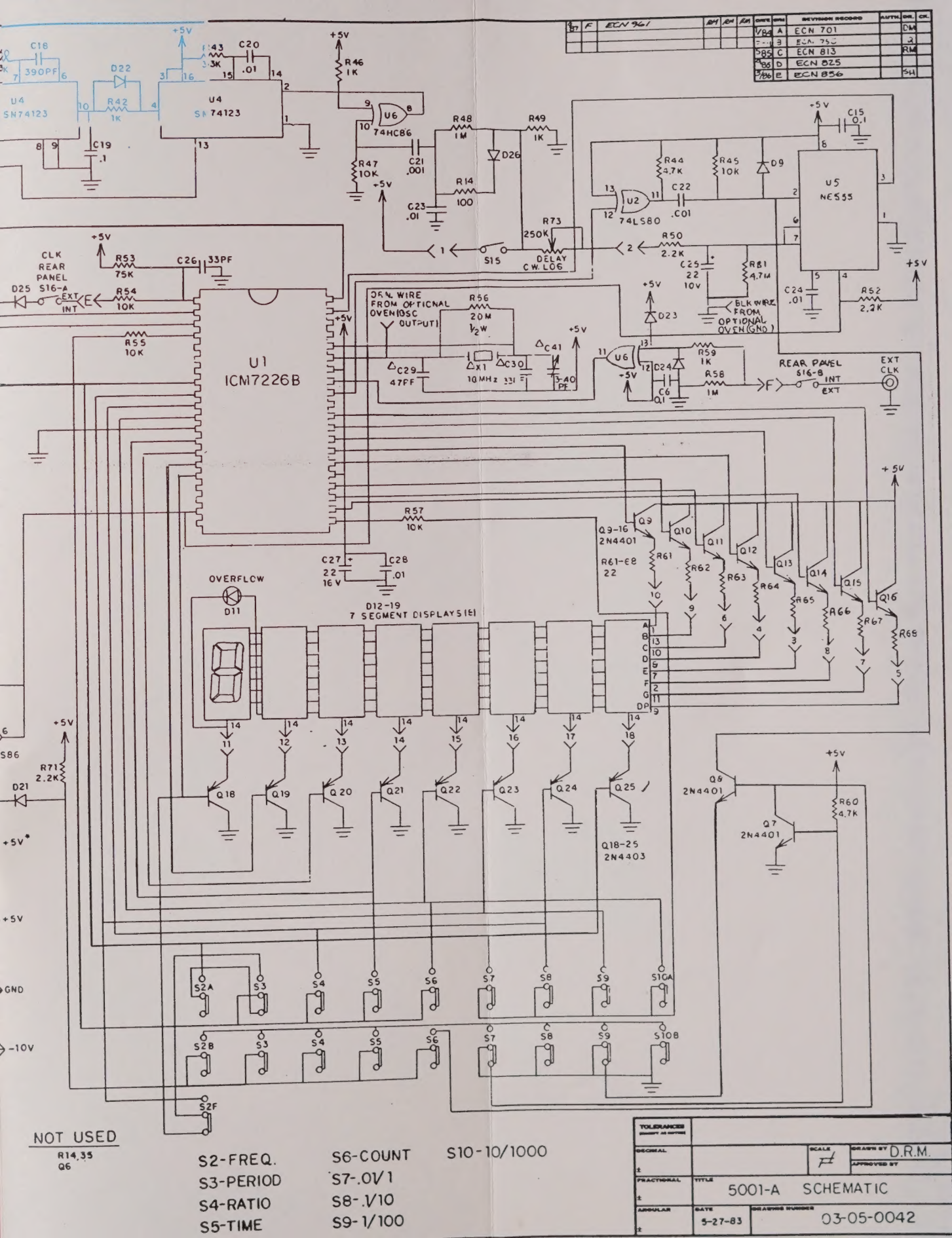
Δ-COMPONENTS NOT USED ON OVENIZED UNIT.

REFER TO 03-05-0046 FOR SCHEMATIC OF OVEN SECTION

*-VALUE 120 OHM WHEN UNIT IS OVENIZED.

LAST USED

R79
C46
D26
Q25
U8
A4
S16
X1
T1
F1




| REV | ECN | DATE | BY | REVISION RECORD | AUTH | CK |
|---|---|---|---|---|---|---|
| | F | ECN 961 | | | | |
| 7/84 | A | ECN 701 | | | | DM |
| 3/85 | B | ECN 750 | | | | JL |
| 5/85 | C | ECN 813 | | | | RM |
| 3/86 | D | ECN 825 | | | | |
| 5/86 | E | ECN 856 | | | | SH |

NOT USED
R14,35
Q6

S2-FREQ.
S3-PERIOD
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S5-TIME
S6-COUNT
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S8-.1/10
S9-1/100
S10-10/1000

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